PROCESS FOR DRILLING DEEP HOLES IN A WORK PIECE

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Zusammenfassung von **CA1298104**

PAT 10756-1 CA 6578 A drill for deep holes in a work piece, is supplied with coolant in the cutting area at the bottom of the drilled hole under a specific operating pressure. A twist drill with 8 hard-metal cutter section and internal cooling channels is used, the coolant operating pressure being controlled in accordance with the depth of the drilled hole, such that it remains above 50 bar. PAT 10756-1

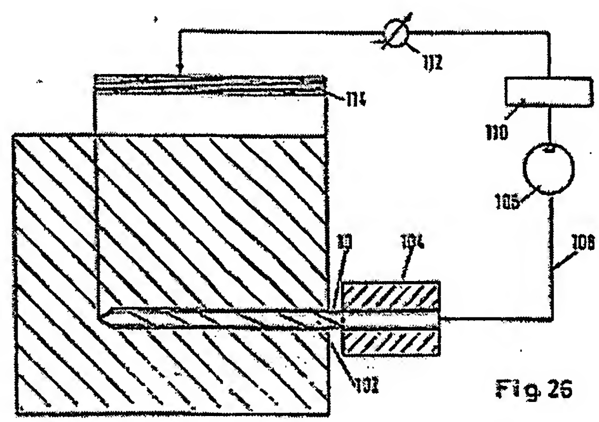

Fig. 26

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(54) Process for Drilling Deep Holes in a Work Piece

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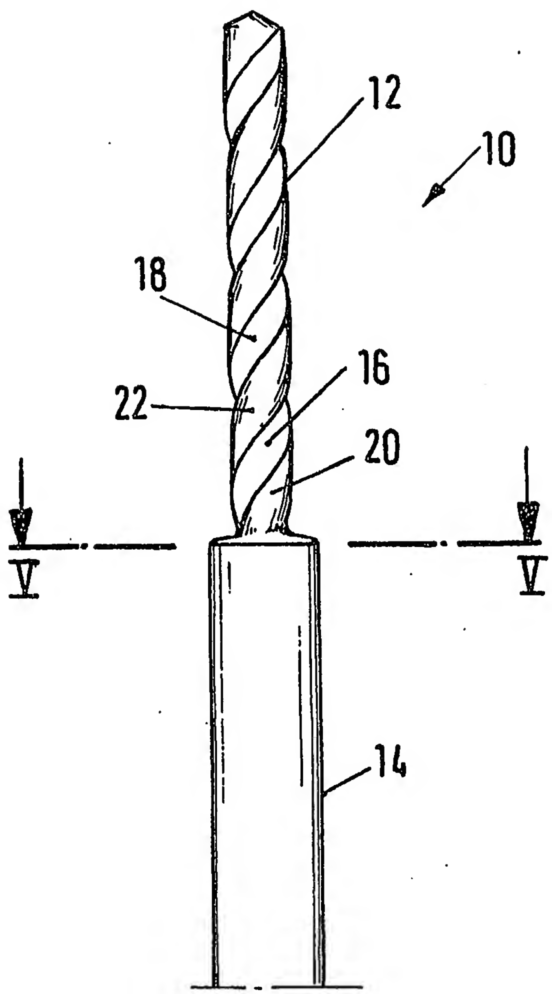
ABSTRACT

A drill for deep holes in a work piece, is supplied with coolant in the cutting area at the bottom of the drilled hole under a specific operating pressure. A twist drill with a hard-metal cutter section and internal cooling channels is used, the coolant operating pressure being controlled in accordance with the depth of the drilled hole, such that it remains above 50 bar.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The present invention relates to a process for drilling deep holes in a work piece.

In the past single-lip drill bits or similarly made drills have preferably been used for this purpose. Because of the configuration and the arrangement of the cutting edges of such drill bits, they are subjected to assymetrical loading. A comparatively short service life results, and the drill must be serviced very frequently. The assymetrical loading, prevents the making of exactly round and precisely oriented holes except with additional expensive measures, for example, by use of a sleeve or bushing.

Further, the tool feed rates which can be achieved with such drill bits are relatively low, which also can be attributed to unequal loading conditions in the cutting area.

It is an object of the present invention to improve the process for drilling drill deep holes whilst increasing the positional and fit precision, the roundness of the hole drilled, and to increase the tool feed rate.

Here disclosed is the use of a twist drill which can withstand heavy loads, in conjunction with control of the fluid pressure in the high-pressure zone of the cutting face which permits feed rates greater by a factor of 7 to 8 compared with those heretofore possible using single-lip drills. Since the tip of the drill can have several cutter sections, it is possible to load the drill bit symmetrically. Use of hard metal as a material for the cutter section increases the stability of the drill bit and the cutting forces at the base of the drilled hole. The ratio of the cross-section of the drilled hole to the cross-section of the drill bit can be reduced so that, in comparison with known processes, a stronger and more durable drill bit can be obtained. The combined features of the present inventive teaching lead to the potential for the hard-metal material to be exploited to the greatest possible extent. Guiding the drill bit over the total length of the drilled hole, results in more even drilling and improvement in the quality and accuracy of the drilled hole.

In apparatus for carrying out the new process the cutter of the twist drill is preferably of fine grain, to prolong the service life of the drill bit.

Proper connection, by way of the described configuration of the drill, between the cooling channels formed within the cutter section of the twist

drill to the pressure fluid line of the pump is important, because of the great demands placed on fluid pressure at the bottom of the drilled hole.

More particularly, in accordance with the invention there is provided apparatus for drilling a deep hole in a work piece at enhanced drill advance velocity, comprising,

a drill motor,

a coolant pressure supply means,

a twist drill coupled to said motor comprising, a hard metal cutter section, and a shank,

said cutter section having a plurality of webs and terminating in a cutting tip,

at least one coolant channel in said shank and a coolant channel defined in said cutter section in a respective at least one of said webs,

means coupling said coolant pressure supply means to said shank for supply of coolant under pressure through said shank and said cutter section to the bottom of said hole adjacent said cutting tip while being drilled; and

a control means connected to said pressure supply means for providing coolant at a pressure in accordance with the depth of said hole while being drilled, pressure of said coolant at the bottom of said hole being maintained in excess of 50 bar,

and whereby cutting chips formed at said cutting tip are thereby rapidly transported away from the region of said cutting tip.

Specific embodiments of the invention will now be described with reference to the accompanying drawings in which;

Figure 1 is a plan view of a twist drill suitable for use in the process for drilling deep holes described;

Figure 2 shows the cutter section of the twist drill in side view;

Figure 3 shows the cutter section in cross-section;

Figure 4 is the shank in side axial section;

Figure 5 is a section on line V-V of Figure 1;

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Figure 6 is an exploded view of a second embodiment of the twist drill;

Figure 7 is an axial section of an embodiment of the shank of the second embodiment of the twist drill;

Figure 8 is an axial section of a further embodiment of the shank of the second embodiment of the twist drill;

Figure 9 is an axial section through the shank, helically grooved, accommodating the adjacent end section of the cutter section;

Figure 10 is a partly sectional view of the connection between the shank and the cutter section of the twist drill;

Figure 11 is a front view of the cooling channel transition element shown in Figure 10;

Figure 12 is a partly sectional view of another connection similar to that shown in Figure 10;

Figure 13 is a front view of the cooling channel transition element shown in Figure 12,

Figure 14 is a partly sectional view of yet another connection, similar to that shown in Figure 10;

Figure 15 is a front view, of the cooling channel transition element shown in Figure 14;

Figure 16 is a front view of a radial transverse channel connection in the cutter section;

Figure 17 is a front view of a transverse channel connection in the cutter section configured differently;

Figure 18 is a partly sectional view of a connection between the cutter section and the shank, both being of the same diameter;

Figure 19 is a front view of the shank of a fourth embodiment of the twist drill;

Figure 20 is a section along line A-A of Figure 19, showing in addition the adjacent end of the cutter section;

Figure 21 is a section along line B-B of Figure 20;

Figure 22 is a front view of the shank portion of a fifth embodiment of the twist drill;

Figure 23 is a section along line A-A of Figure 22, additionally showing the adjacent end of the cutter section;

Figure 24 is an exploded view of the transition zone of the twist

drill of Figures 22 and 23;

Figure 25 is an exploded view of the transition zone of the twist drill, in which two connector channel sections are provided.

Figure 26 is a schematic drawing partly in section of apparatus illustrating the principles of the process embodying the present invention.

A work piece 100, shown in cross-section in Figure 26, is to be drilled by a twist drill 10 whose structure will be detailed later so as to produce a hole 102. The drill 10 is mounted in, and rotated by, the drill motor 104, shown schematically. Instead of applying a rotational movement to the twist drill 10, it is also possible to rotate the work piece 100 and secure the twist drill 10. It is also possible to rotate both parts in opposite relative directions. One of the two elements must also be subjected to a feed motion with respect to the other.

In the illustrated embodiment, the drill 10 is subject to both a rotational movement and by means of suitable rotatable fluid coupling a feed movement.

The drill motor 104, and through it the cooling channels (to be described) formed in the twist drill 10, are connected to a fluid line 108 pressurized by pump 106. Fluid pressure is transferred to the bottom of the drilled hole through the cooling channels and the value of the pressure supplied by the pump is controlled so that there is always a minimum pressure of at least 50 bar at the bottom of the hole. To maintain this minimum pressure level independently of the depth of the hole already drilled, the output of the pump 106 must increase directly with the depth of the hole drilled, to the extent required also to compensate for the increased effort required to remove and evacuate the drill shavings. Pressure control is effected by a control system 110 to which is supplied, in the illustrated embodiment, a variable electrical signal derived from a resistive element 114 having a slider whose position is dependent upon the depth of the drill in the hole. Pre-set 112 allows compensating adjustments to be made.

Any other control system 110, in which the fluid pressure from the fluid pump increases with increasing depth of the drilled hole, can be used.

The twist drill 10 shown in Figures 1 to 4 is divided essentially into two sections, the cutter section 12 and the shank 14.

The cutter section 12 is entirely of hard metal and, in the embodiment

shown, has two flutes 16, 18 on the outside surface of the cutter section 12 staggered by 180 degrees relative to one another and which constitute a chip space through which the shavings are removed from the bottom of the drilled hole.

The flutes 16, 18 are defined by two drill webs 20, 22 within each of which there is a cooling channel 38, 40 set radially outwards from the axis of the bit. The outer surfaces of the drill webs 20, 22 have lands, by which the cutter section 12 of the twist drill 10 is guided or centered, within a drilled hole. The shank 14 serves to transmit the forces to the cutter section 12 being connected by a slip-free coupling to the output shaft of the drill motor.

To connect to the cutter section 12, the shank 14 is provided, as shown in Figure 4, with a recess 24, the inside diameter of which is approximately the same as the outside diameter of the cutter section 12. Within the area of the opening surface of the recess 24 the outside surface of the cutter section 12 is connected to the inner wall of the recess 24 within the shank 14, as is shown in Figure 5. The lands are soldered to the inner wall of the recess 24 and adhesive 19 is placed in the flutes close to the opening surface. The adhesive bond formed is intended to last throughout the service life of the twist drill 10 and serves to fill the cavity formed by the flutes 16, 18 in the area of the opening surface, to prevent the ingress of chips into recess 24 within shank 14. Preferably the grain size of the material forming the cutter section 12 is less than 1 micron.

In a further embodiment, shown in Figure 6, the outer end of the recess 24 is closed by a plate 26. The plate 26 forms an opening, whose cross-section matches that of the cutter section 12. The end of the cutter section 12 remote from the tip of the drill is slid axially through the plate opening 26 and into the recess 24, by giving it a rotary motion required by the form fit, until its tip rests against the bottom of the recess 24. In this embodiment, torque for the drill is transmitted essentially from the shank 14 by means of the shape and force locking fit between the plate 26 (connected rigidly with the shank 14) and the cutter section 12. The soldered joint between the corresponding matching surfaces in the bottom of the recess 24 which have still to be described, prevents cooling medium escaping into the chip space. The chemical resistance of this soldered connection must be

sufficient to prevent corrosive action by the cooling medium throughout the service life of the cutter section 12.

Instead of the arrangement shown in Figure 7, in which the plate 26 is shown as a separate element fixed rigidly to it, the shank 14 can be formed in one piece with an annular projection 28, the cross-section of which matches the plate 26 overall and which projects radially inwards, as is shown in longitudinal section in Figure 8.

Figure 9 shows the shank 14 of the twist drill 10, which has an internally threaded section 15 configured to correspond to the shape of the cutter section, the overall axial overlapping length between the cutter section 12 and the shank 14 being usable for transmission of working loads.

Figures 10 to 15 show embodiments of the connection between the cooling channels 38, 40 of the cutter section 12 to the cooling channel 44 of the shank 14 and for sealing the connection. Between the face side of the cutter section remote from the drill tip and the bottom of the recess 24 in the shank 14 there is in each instance a cooling channel transition element 28, 30, 32. This element is connected to both the shank 14 and to the cutter section 12 so as to be leakproof. There is thus no need for additional measures to ensure a seal between the cooling channels and the chip space. Since the connecting surfaces between the shank 14 and the cutter section 12, which serve to transmit the forces encountered, are not exposed to the cooling medium, they can be made more cheaply, or in certain circumstances, be dispensed with when torque being transmitted by shape or force locking.

The cooling channel transition element 28 shown in Figures 10 and 11 has two separate cooling channel sections 34, 36; these are parallel and extend in the axial direction of the drill 10, thereby connecting the cooling channels 38, 40 of the cutter section 12 separately, with a wider section 42 of the end of the cooling channel 44 in the shank 14.

The cooling channel transition element 30 shown in Figures 12 and 13 has two mutually inclined cooling channel sections 46 and 48; each runs from a common connection 50 in the cooling channel 44 of the shank 14 to a respective end opening of the cooling channels 38, 40 of the cutter section 12.

Figures 14 and 15 show a cooling channel transition element 32 with a slot 49, through which the whole centre section of the face end of the cutter section 12 located within the recess 24, and thus the two open end surface of

the cooling channels 38, 40 of the cutter section 12 are connected to the cooling channel 44 in the shank 14.

Where the cooling channel transition element has only one opening, which does not cover both the openings of the cooling channels 38, 40 formed in the cutter section 12, a groove-like depression 52 is formed in the corresponding face surface 13 of the cutter section 12 as a transverse channel connection extending across the total diameter of the cutter section 12 or, as in Figure 17, only across its mid-section.

With a cutter section diameter approximately the same as that of the shank 14, an assembly section 56 is formed in the end section of the cutter section remote from the cutting tip by a radial step or necked-down section, used to join both parts. The outside diameter of this assembly section 56 corresponds to the inside diameter of the recess 24 formed in the shank 14. An embodiment is shown in Figure 18.

The shank 14 shown in Figures 19 to 21 has a face side 13a in the transition section, and this is formed by a hollow-edge recess 14b. The two flat surfaces forming the recess 14b intersect in the middle of a slot 14a which connects the openings forming the cooling channels 38, 40 in the face side 13 of the cutter section 12, with the central cooling channel 44 in the shank 14. The faces 13 and 13a are soldered to one another, which prevents leakage of coolant into the chip space formed by the flutes 16, 18. Effective transmission of the torque is ensured by the shape locking fit particularly at the periphery of the twist drill where the prism-shaped tip of the end of the cutter section 12 engages in the recess 14b in the shank 14.

Figures 22 to 24 show a twist drill similar to the one described above but, in this instance, the prism-shaped tip 13 of the cutter section 12 and the hollow wedge recess 14b of the shank 14 are interchanged. The functions and the effects correspond to those described for the embodiment of Figures 19 and 20.

Figure 25 shows an alternative possibility for the connection for the cooling channels 38, 40 of a twist drill similar to the one shown in Figures 19 to 24. Here, connecting channel sections 14d and 14e are formed in the transition zone between the shank 14 and the cutter section 12, in place of the slot recess 14a. These connect each cooling channel 38, 40 individually with the cooling channel 44 in the shank 14.

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. Apparatus for drilling a deep hole in a work piece at enhanced drill advance velocity, comprising,

a drill motor,

a coolant pressure supply means,

a twist drill coupled to said motor comprising, a hard metal cutter section, and a shank,

said cutter section having a plurality of webs and terminating in a cutting tip,

at least one coolant channel in said shank and a coolant channel defined in said cutter section in a respective at least one of said webs;

means coupling said coolant pressure supply means to said shank for supply of coolant under pressure through said shank and said cutter section to the bottom of said hole adjacent said cutting tip while being drilled; and

a control means connected to said pressure supply means for providing coolant at a pressure in accordance with the depth of said hole while being drilled, pressure of said coolant at the bottom of said hole being maintained in excess of 50 bar,

and whereby cutting chips formed at said cutting tip are thereby rapidly transported away from the region of said cutting tip.

2. Apparatus as defined in claim 1, the cutter section being of fine grain with a maximum grain size of 1 micron.

3. Apparatus according to claim 1 or 2, wherein the webs of said cutter section of the twist drill comprise guiding lands for guidance contact with said hole over that entire length of said cutter section within said hole being drilled.

4. Apparatus as defined in claim 1, the cutter section (12) having at least two spiral flutes (16, 18) which together form a chip space and extend the length of the cutter section, the cutter section (12) being connected at its end remote from the drill tip to the shank (14) by configured adjacent face surfaces (13, 13a), the cooling channels (38, 40, 44) being sealed off from the chip space by means of soldered matching surfaces between the cutter section (12) and the shank (14).

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5. Apparatus as defined in claim 4, characterized in that the end of the cutter section (12) remote from the drill cutting tip is inserted into a matching recess (24) in the shank (14).

6. Apparatus as defined in claim 5, characterized in that the recess (24) in the shank (14) is cylindrical and conforms to the outside diameter of the cutter section (12).

7. Apparatus as defined in claim 5, characterized in that sealing is effected by way of a face surface (13) of the cutter section (12) lying against a correspondingly shaped contact surface at the bottom of the recess (24).

8. Apparatus as defined in claim 7, characterized in that the shank (14) has a central cooling channel (44), the diameter of which is smaller than the diameter of the cross-section of the cutter section (12) and connects to the two cooling channels (38, 40); the contact surface being formed by the bottom of the recess (24).

9. Apparatus as defined in claim 5, characterized in that the face surface (13) of the cutter section (12) lies against a contact surface of a cooling channel transition element (28, 30, 32) at the bottom of the recess (24) in the shank (14), the cooling channel (44) in the shank (14) directionally branching to respective cooling channels (38, 40) in the cutter section (12).

10. Apparatus as defined in claim 9, characterized in that the cooling channel openings on the face side (13) of the cutter section (12) are connected singly to corresponding openings of the cooling channel transition element (28, 30, 32).

11. Apparatus as defined in claim 8 or claim 9, characterized in that the cooling channels (38, 40) in the cutter section (12) are connected by means of a radial transverse channel connection (52) arranged on its face surface (13).

12. Apparatus as defined in claim 8 or claim 9, characterized in that the cooling channel transition element (32) is a force fit in the recess (24) and has a slot (49) into which the cooling channels (38, 40) of the cutter section (12) open out.

13. Apparatus as defined in claim 2, characterized in that between the cutter section (12) and the shank (14) adjacent the opening surface of the recess (24) a layer of adhesive fills the flutes (16, 18).

14. Apparatus as defined in claim 2, characterized in that the recess (24) is configured with a helical internal thread section (15), in which a corresponding section of the cutter section (12) is a force fit.

15. Apparatus as defined in claim 14, characterized in that the internally threaded section (15) extends axially the whole length of the recess (24).

16. Apparatus as defined in claim 2, characterized in that the recess (24) is closed off by a plate (26) which, defines the opening to the recess (24), and conforms to the cross-section of the cutter section.

17. Apparatus as defined in claim 16, characterized in that the plate (26) is formed in one piece with the shank (14).

18. Apparatus as defined in claim 16, characterized in that the plate (26) is formed separately and is connected rigidly to the shank (14).

19. Apparatus as defined in claim 4, characterized in that the adjacent face surfaces (13, 13a) respectively of the cutter section (12) or the shank (14), respectively, are formed as matching surfaces such that their planes intersect; the shank (14) and cutter region (12) being connectable and shape-locking at their peripheries, the cooling channel (44) of the shank (14) being connected by the end section of the shank (14) to the individual cooling channels (38, 40) of the cutter section (12).

20. Apparatus as defined in claim 19, characterized in that the face surface (13) of the cutter section (12) is prism shaped and projects and fits into a correspondingly shaped recess (14b) in the face (13a) of the shank (14).

21. Apparatus as defined in claim 19, characterized in that the face (13a) of the shank (14) is prism shaped and projects and fits in a correspondingly shaped recess (13a) in the face surface (13) of the cutter section (12).

22. Apparatus as defined in claim 19, 20 or 21, characterized in that a slot-like recess (14a) is provided in the end section of the shank (14) to connect the cooling channels (38, 40) of the cutter section (12) to the cooling channel (44) in the shank (14), through which the cooling channel (44) in the shank (14) is widening to the individual cooling channels (38, 40) of the cutter section (12).

23. Apparatus as defined in claim 19, 20 or 21, characterized in that connection of the cooling channels (38, 40) of the cutter section (12) to the cooling channel (44) in the shank (14), is effected by connector channel sections (14d, 14e) being provided in the end section of the shank (14), each of which runs from the cooling channel (44) to one of the cooling channels (38, 40).

24. Apparatus as defined in claim 14, 15 or 18, characterized in that the section of the shank (14) that forms the recess (24) is a cast body.

25. Apparatus as defined in claim 14, 15 or 18, characterized in that the shank (14) is a cast body.

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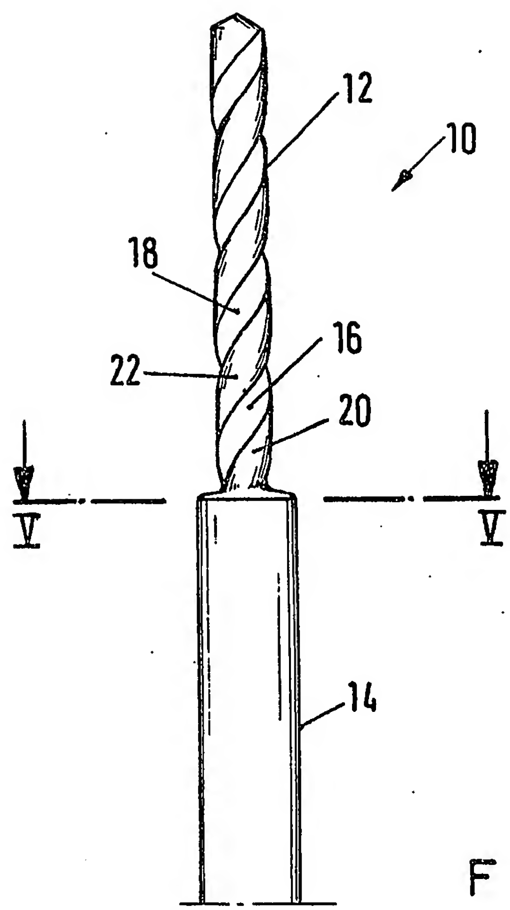

Fig.1

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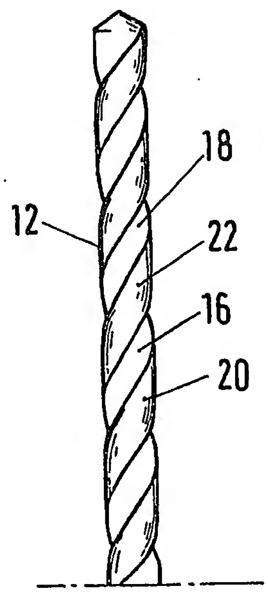

Fig. 2

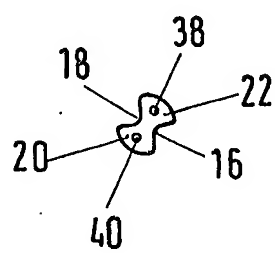

Fig. 3

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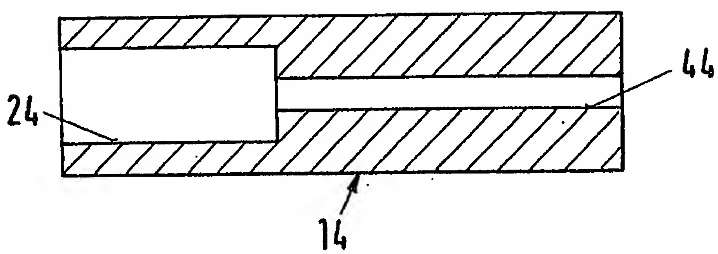

Fig. 4

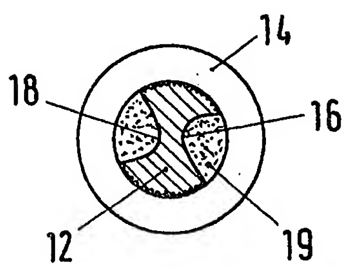

Fig. 5

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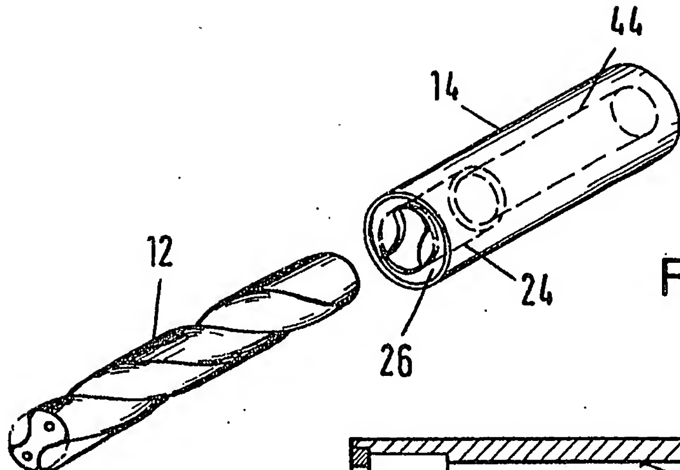


Fig. 6

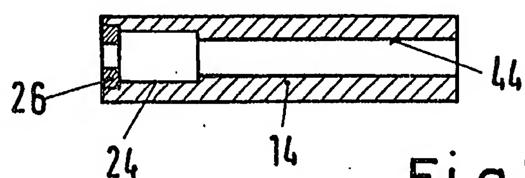


Fig. 7

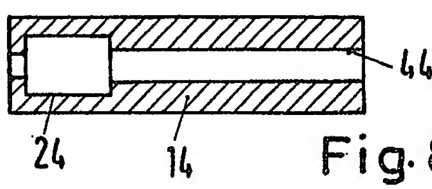
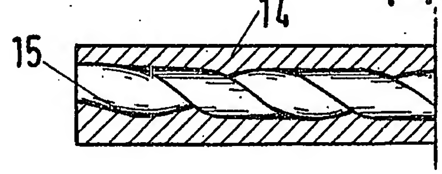


Fig. 8

Fig. 9



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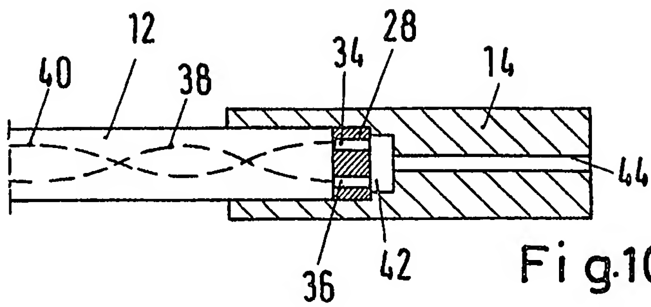

Fig.10

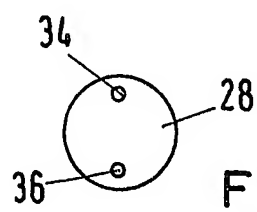

Fig.11

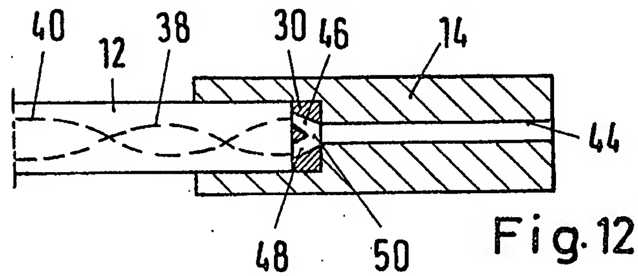

Fig.12

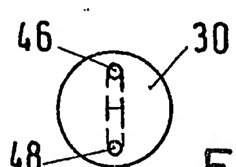

Fig.13

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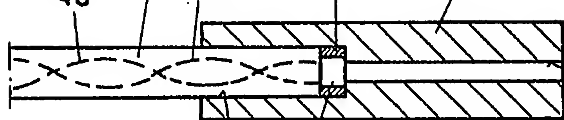

Fig. 14

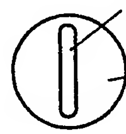

Fig. 15

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Fig.16

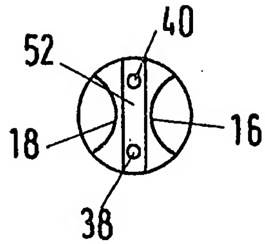


Fig.17

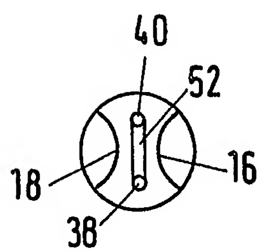
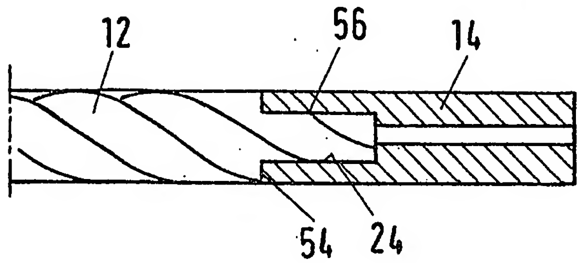


Fig.18



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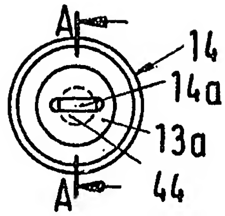


Fig. 19

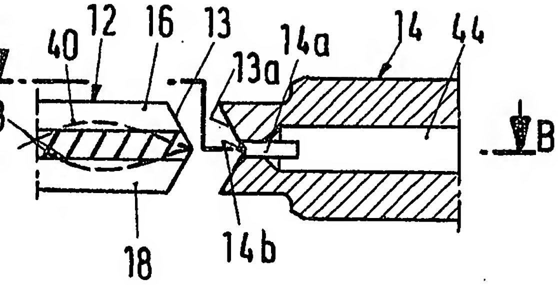


Fig. 20

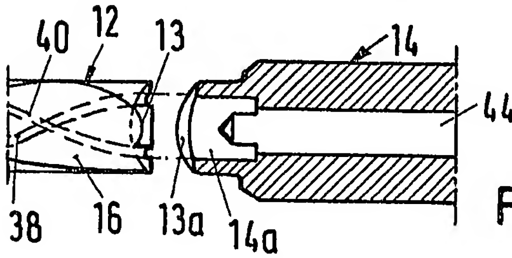


Fig. 21

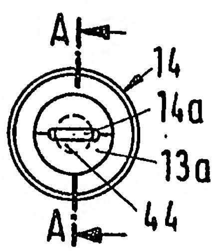
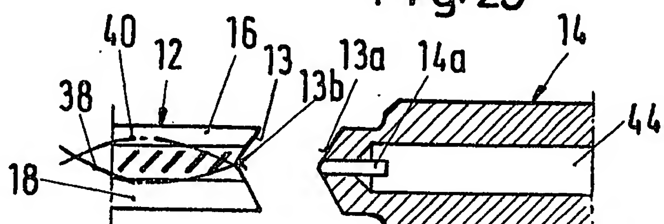


Fig. 22

Fig. 23



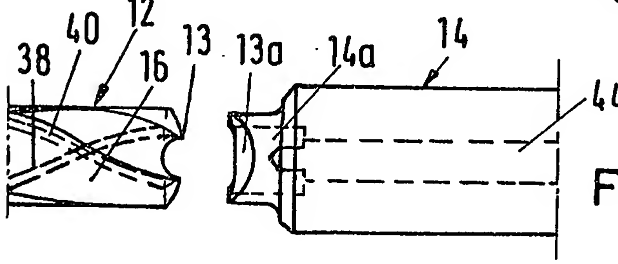


Fig. 24

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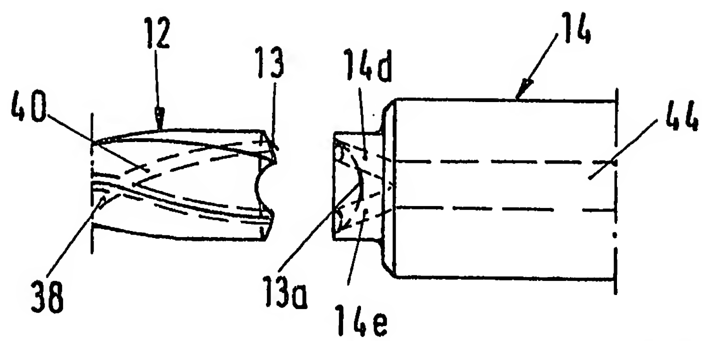

Fig. 25

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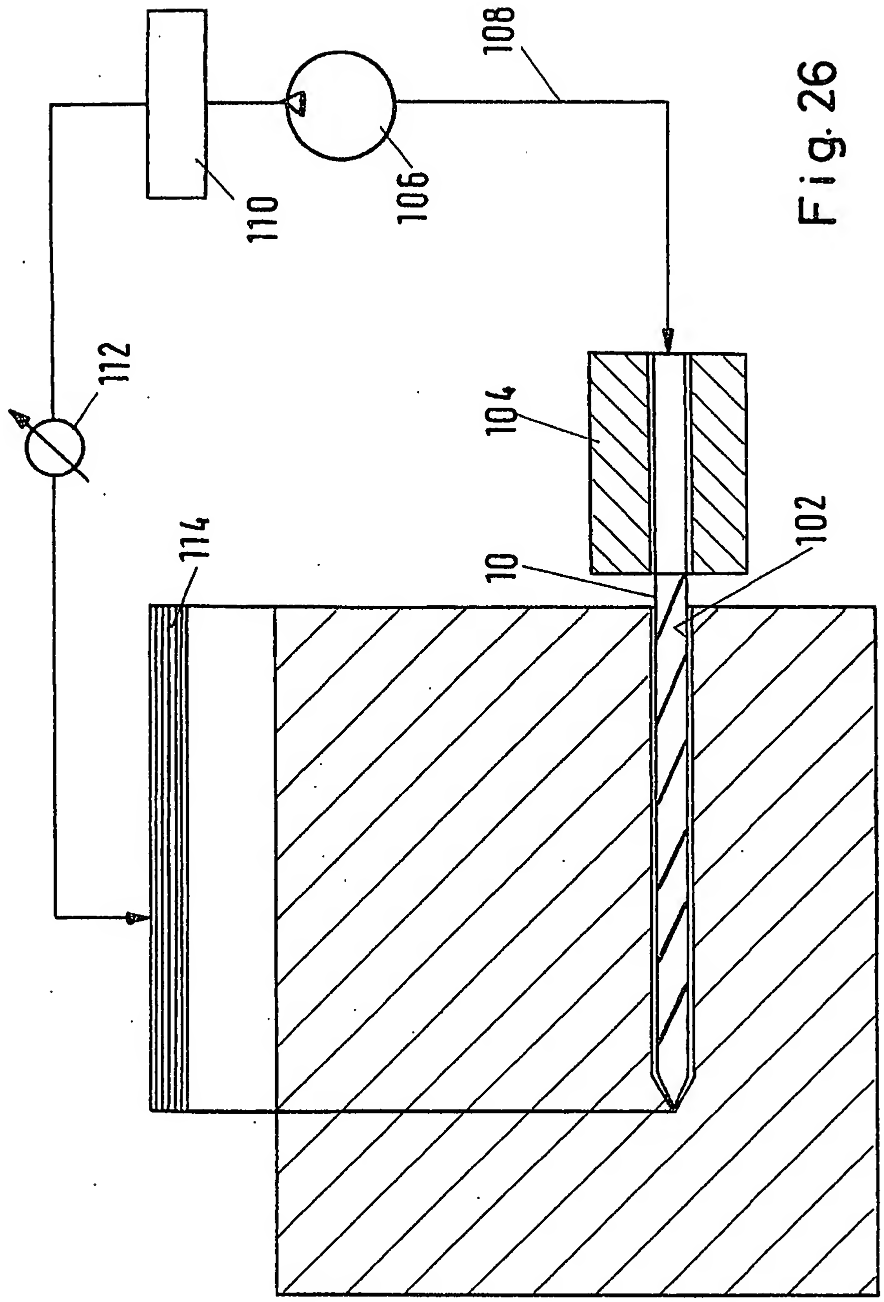

Fig. 26

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